10th International Conference on
Computer and IT Applications in the Maritime Industries

COMPIT’11

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Welcome to the 10th COMPIT Conference

Greetings from Erik van der Noordaa, CEO GL Group

The maritime industry could not survive without modern information technology. Today, the informed public and legislative bodies all over the world expect that shipping contributes to fighting global warming and reduces its carbon footprint. While the industry encounters a period of tightening emission limits, commercial pressures and fuel surcharges, substantial savings are only feasible by advanced applications and programs.

This simple observation corresponds with the idea of the Conference for Computer and IT applications in the Maritime Industry. COMPIT has and will continue to promote the dialogue between the maritime and IT industries as well as key research groups from academia. If the conference had not been initiated ten years ago, it would be high time to get started and enter a new phase of energy efficiency. While there are many other exciting topics on the agenda of the 10th Conference for Computer and IT applications in the Maritime Industry, the ultimate challenge is to provide smart technical solutions.

Today's ability to undertake even more complex simulations vastly improves the scope and sophistication of designs and their integrated environments. This is reflected by the introduction of commercial software tools which help to address the dominant topics of fuel efficiency and emission reduction.

Looking beyond the urgent requirements for shipping, advances in individual and swarm intelligence are opening up new applications in surveying and search tasks, in offshore, oceanography and navy applications. The conference covers a broad spectrum of themes which apart from the life cycle of ships, offshore structures and equipment, address frontier developments of a highly complex nature.

I wish everyone an inspiring exchange of ideas!

Erik van der Noordaa
CEO GL Group
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Call for Papers COMPIT’12
Trends in Industry Applications of CFD for Maritime Flows

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Abstract

The paper surveys developments in CFD applications for maritime structures (ships, propellers and offshore structures) over the past decade. Progress is significant in integrating the process chain, particularly more automated model generation. Increased hardware power and progress in various aspects of the flow solvers allow more sophisticated applications and wider scope of applications. Selected examples taken from industry and research applications show the increasing importance of CFD in earlier design stages.

1. Introduction

Computational fluid dynamics (CFD) denotes collectively techniques solving equations describing the physics of flows. We interpret “CFD” here as techniques solving Euler, RANSE (Reynolds Averaged Navier-Stokes Equations) or Navier-Stokes equations, using field methods, Ferziger and Peric (2010), Bertram (2012).

Fig.1: Simulation of coolant flow in an engine block in 1988

Fig.2: Modern CFD analyses with high level of detail
CFD became a research field in the late 1960s. First commercial CFD software appeared in the 1980s including codes like PHOENICS, FLUENT, STAR-CD, CFX, TASCFLOW, and FLOW3D. By today’s standard, these codes were very limited in terms of complexity of geometry and physics. Applications were severely limited by the available computer power in those days. An example may illustrate how CFD progressed over the decades. In 1988, an advanced CFD application in the automotive industry investigated the coolant flow in an engine block using some 10000s of cells, Fig.1.

Two decades later, the progress in CFD allows the simulation of fluid and heat flows in engine compartments with some 700 parts and typically around 30 million control volumes, even 100 millions for detailed studies, Fig.2. However, the increase in grid size and associated capturing of geometry and flow details is only one aspect of the CFD developments of the past decades. It is a perhaps surprising fact that computational times have increased over the years. The demand for ever more ambitious simulations (in terms of cell count and flow complexity) thus outpaced the exponential growth in computational power.

Despite the increase in average computational time, CFD projects today are often noticeably shorter than they were two decades ago. This is due to less frequent re-modelling and re-analyses, and also generally significantly reduced time in pre-processing. The reason is that CFD tools have become more user-friendly, Fig.3. This is perhaps best illustrated in the case of integrated design environments, e.g. the Friendship Framework, Abt and Harries (2007). The integrated design environment combines freeform hull description using parametric modelling, interfaces to most modern CFD solvers including STAR-CCM+, several optimization algorithms, and software to handle process management and user interface. The design engineer can then work on simulation driven designs (e.g. of hulls, appendages or propellers) with one integrated user interface from model generation to post-processing. The user-friendliness of this approach has certainly lowered thresholds in using CFD for designers.

There are many more aspects that have in sum advanced the wide acceptance of simulation first as a design and more recently as an optimisation tool in industry. The most important among these aspects are:
• The ability to handle complex geometry with all relevant details, including moving parts;
• Efficient simulation process (from geometry to solution, parametric studies, optimization studies, user interface...);
• Adequate modelling of turbulence, free-surface effects and cavitation;
• Coupled simulation of flow and flow-induced motion (and in some cases deformation) of bodies.

These will be discussed in more detail in the following.

2. Key aspects of progress in CFD for maritime flows

2.1. Handling of complex geometry

During the past decade, the ability to handle complex geometry with all relevant details has been greatly improved. Components that have contributed to this trend include:

• Tools for automatic and user-friendly manual repair of CAD models (which are often imperfect) have been developed; IGES files coming from designers frequently feature overlaps and gaps. These are not problematic for design purposes (e.g. volume computations are required for ship stability and capacity), but frequently lead to fatal errors for CFD grid generation.
• Surface-wrapping tools have been introduced, which create a closed surface around assemblies of solid parts, Fig.4;
• Tools for automatic generation of polyhedral, trimmed hexahedral or extruded meshes have been developed;
• Automatic and manual definition of local mesh refinement requirements have been created, based on:
  − local curvature, proximity of other walls etc.;
  − pre-defined regions, interfaces, wakes etc.;
  − indication or estimate of numerical error...

Grid generation has improved, making it easier to generate high-quality grids for accurate CFD simulations. A key aspect for complex geometries consisting of many components (such as offshore platforms in the maritime context) is geometry recognition. The software then recognizes automatically cylinders (with extrusion along centreline, using prismatic cells) and thin solids or gaps, with projection from one side to another, using prismatic cells).

Fig.4: Re-meshed surface of a complete oil rig after surface-wrapping (left) and simulated air flow field around the oil rig with surface pressure and wake velocity (right)

More sophisticated analyses for ships and offshore platforms employ a variety of techniques that have become widely available (through commercial and open-source software):